NEW EXPERIMENT STATION BUILDING.

1359 Issued July 17, 1911.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Special Agent in Charge.

# ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1910.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

# CONTENTS.

## ILLUSTRATIONS.

# ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1910

## SUMMARY OF INVESTIGATIONS.

By D. W. May, *Special Agent in Charge.*

### INTRODUCTION.

Whatever may be the results in the various efforts made by the United States Government in improving the condition of alien peoples there can be no doubt as to the material improvement in the living conditions of the people of Porto Rico. In a few years a prosperity has been reached hitherto unknown in the history of Porto Rico. This has been brought about on an impoverished soil and in a country where the natural resources have been practically exhausted.

The prosperity of Porto Rico depends essentially on her agricultural products. Gold mining is exhausted and manufacturing is confined to a very few lines and a small output. While the island is thickly populated, more so than any of the States except two, the people are scattered through the country rather than in towns. They live from the soil.

The exports and imports representing the trade of the island in 1901 was $17,502,103. In 1910 it had increased to $68,595,074. This trade is due to the greatly increased agricultural production of the island, which has not only given impetus to all the industries, but has greatly improved the living conditions of our people.

The resources of Porto Rico reside in her soil and labor. That these languished in years gone by was not due to the sterility of the one or the unwillingness of the other, but to a lack of enterprise. The latter has been inspired by a conservative government, the introduction of capital, and a broadening market.

### SUGAR.

Of the $37,960,219 of exports during the fiscal year 1910, sugar and molasses totaled $24,145,046. Since the earliest times Porto Rico has been noted for the quality of her sugar cane. The strip of level land bordering her seacoasts has been mainly devoted to this crop. Since the American occupation this industry has had a phenomenal growth, brought about by favorable trade relations with the United States,

the installation of modern equipment in both the cultivation and the grinding of the cane, and in modern methods of culture. Although the cane acreage has been increased, the greater gain has resulted from a better preparation and cultivation of the soil and the application of fertilizers. The greatest increase in the future production of sugar on the island will be brought about by more intensive cultivation, augmented to some extent by a larger acreage planted to cane.

Owing to the profit of cane growing under present conditions in Porto Rico the planter endeavors to continue this crop on the land without rotation. This is contrary to the best practice in agriculture, and, to succeed, the grower must apply an unusual skill or disaster will overtake him. The first endeavor among progressive planters has been the changing of varieties, especially the introduction of the new productions obtained from the seed. The experiment station has for several years been engaged in breeding new canes and importing those of other stations in the West and East Indies. The aim in this work is to secure a cane of larger tonnage, greater sweetness, and resistance to disease.

During the year a bulletin embodying the results of experimental work along several lines was issued in both English and Spanish. The work with cane consists in breeding new varieties, the study of diseases, and especially investigations in cane soils. The latter is directed to the amelioration of lands that have been planted to cane for many years and which as a result have become " tired " or " sick." This applies especially to the study of the biological conditions. The means employed in improving such soils is disinfecting by the use of various chemicals.

The sugar planters, realizing the importance of scientific research in the improvement of their industry, have organized their own station for the study of the questions directly affecting sugar production. A tract of land has been purchased and a staff selected. The various phases and factors influencing sugar production will be studied. This station, working in harmony with the Federal station, will greatly profit the industry in Porto Rico. It will also relieve to some extent the latter station, which is endeavoring to cover many lines of work in the large and important field of tropical agriculture.

## COFFEE.

There was sold from the island during the year coffee to the value of $5,669,602. Of this amount only $21,876 went to the United States. Naturally a product goes to its best market, and the sales in this instance indicate that our coffee is better appreciated in foreign than in the home markets. The cause is not far to seek. Coffee, like other beverages, is rated upon its flavor or aroma. The preference

of a people in this regard is largely a matter of training or habit. The trade on an article of uniform quality, as sugar, will change quickly with trade relations, but a variable product, as coffee, changes its lines of trade very slowly.

In most of the countries of Europe and former colonies of Spain, as Cuba, the peculiar flavor of Porto Rican coffee is relished. In the States a highly flavored coffee, as certain classes of Java, has the preference. The Porto Rican coffee is the highest type of after-dinner black coffee. The home market prefers another type. In the States Porto Rican coffee is not properly made. Here the bean is roasted black, in the States it is browned. The method followed here is the proper one for a black after-dinner coffee; that in the States is correct for a highly flavored coffee where it is desired to preserve the peculiar aroma contained in the essential oil.

It is hard to change the taste of a people, and it is often more profitable to cater to it than to attempt to change it. As long as the present type of coffee is grown in Porto Rico it must be marketed abroad. If the market in the States promises better returns, then the type of coffee that will meet the demands there and command the highest prices must be grown.

Our experiments indicate the possibility of growing Java and other coffees and maintaining their peculiar flavor. It will take more time, however, to determine how these coffees will be received in the States markets. It is necessarily slow to change a product grown on trees owing to the time in which they reach a stage of profitable production. Seeds of introduced varieties of coffee have been distributed, and a number of planters are making practical comparisons with native coffee.

There is a marked improvement in the condition of many plantations, and with the higher prices now ruling proprietors are giving better cultivation to their trees in both cleaning and pruning and in some instances in fertilization.

There is also a growing tendency to a greater diversification of agricultural products. Planters are finding that other things than coffee pay on the mountains of Porto Rico. Where accessible to roads budded oranges and grapefruit are being planted and in many instances wild trees have been budded over. Other products, as bananas and charcoal, are being marketed in the near-by towns. This is a move in the right direction, for in a country of small proprietors such as this the one-crop idea will not succeed.

## TOBACCO.

Tobacco is third in value of the crops produced on the island. With the added value through manufacture, the exports aggregated $5,763,214. The most notable feature of this production is the

increase of local manufactures. This is about the only line in which manufacturers have taken advantage of the large supply of labor. The industry is likely to show a great increase, as the supply of labor is large and, moreover, is of a class singularly adept in making cigars and cigarettes. There was imported during the year for the purpose of manufacture tobacco leaf to the value of $370,645. There was exported, however, leaf tobacco to the value of $1,140,904. Cigar tobaccos solely are grown in Porto Rico. Cigar wrappers are grown under cheesecloth and this part of the industry is carried on by companies with considerable capital. The large part of the filler tobaccos, which are grown in the open, is produced by small planters. The tobacco companies largely manufacture their product; the small grower sells for what he can get in an open and rather restricted market. Having no organization, the prices he receives are low. There has been a trend toward lower prices for several years, and persons who have come to Porto Rico for the purpose of growing tobacco to sell in the leaf have lost considerable money. With but a few buyers on one side and an unorganized lot of producers on the other, and with new and unknown pests to contend with, the tobacco grower has had a hard time.

Greater skill is required to grow tobacco in the Tropics than in the north. The soil itself presents more problems and the seasons are more variable. The insect pests are more numerous and formidable. Losses in Porto Rico have been especially heavy in the seed bed. Some method must be devised for disinfecting the seed bed before planting. Burning the ground before sowing the seed, as practiced in the States, would doubtless prove of value. In some cases studied by the station losses in the seed bed have been occasioned by nematodes.

## FRUIT.

The agricultural pursuit capable of the greatest expansion in Porto Rico is fruit growing. This is due to the great area of land capable of producing some class of fruit and especially to the enormous production of tree fruits on a given area. Most of the planters who have come to the island since the American occupation have engaged in fruit growing. This industry has shown the greatest growth. From shipments of wild oranges five years ago to the value of $125,311 there has been an increase to last year of fruits valued at $1,416,947. Of this amount oranges totaled $582,716, pineapples $555,044, grapefruit $162,749, and canned pineapples $106,587. Some other fruits are coming on the market, as the mango, and give promise of making a commercial success.

The progress in fruit growing has been made under most trying circumstances. Soils employed for this purpose have been depleted

largely of their fertility. In most localities they are wind swept. Again, fruit growing here is a pioneer industry and methods must be worked out by experience, which is always expensive. Even conditions that seemed similar to those obtaining in older fruit-growing countries were found to vary when practically tested in Porto Rico.

Failure has resulted from lack of experience with some planters and from lack of application with others. Again, some companies with glittering prospectuses have not made good and as a result investors have lost large sums of money in Porto Rico, thus causing much injury to the country and the fruit industry.

To succeed in fruit growing in Porto Rico a capable, honest, and industrious manager is very essential. He must reside on the land and give it his constant and unremitting attention, for disaster lurks in every season. Planting the tree and waiting for results will fail every time.

## COCONUTS.

Among the miscellaneous products the coconut brings the greatest revenue into the island. It is grown in a comparatively small area, the fringe of sandy beach bordering the coast line. The nuts are of superior quality, easily grown, and bear abundantly. It is almost impossible to buy a bearing grove. The area planted shows some increase, but the soils best adapted to the crop are pretty well taken up. The yield could doubtless be much increased by more fertilization and better cultivation. In most cases the groves are unplanted to other crops, though it is a good practice to grow small cultivated crops, especially beans, among the trees. The nuts are shipped whole to New York and are used largely by the makers of desiccated coconut for use in pastry, etc. About seven years are required for the trees to come into profitable bearing, but after that the crop is sure and the cost of maintenance low. The coconut-bud rot is not known to occur here and such pests as are present are easily controlled.

## LIVE STOCK.

The trade in live stock in the island has undergone a complete change in a few years. From exports of three to four hundred thousand dollars of a few years ago it has dwindled to nothing; on the contrary, animals both alive and as dressed meat are now a large item of imports.

This change has been brought about by the greatly increased needs for work animals and also the greater consumption of meats due to an increased prosperity. Animals of all classes, especially horses, have increased greatly in price. Dressed meats also have become a luxury and beyond the reach of most of the laboring classes. Chilled meat is shipped in from the States, and dried or jerked beef from Argentina.

The experiment station has devoted considerable effort to importing pure-blooded animals, and studies have been made in the practical methods of handling and feeding domestic live stock in the Tropics. A study of the influence of certain mineral nutrients on animal growth, which has developed some interesting results, is in preparation for printing.

## FIBERS.

Sea-island cotton is the principal fiber crop in Porto Rico, but its culture has made little progress, and it can hardly be called an industry. It is grown by small planters, who do not give the crop the attention it deserves. They neither produce, as a rule, the good quality that should be expected nor understand handling or marketing their product. It is usually bartered to the local merchant, who does not offer a price based on the quality, a practice which would lead to the best efforts on the part of the grower.

There is no doubt of the quality of Sea-island cotton on the best lands. Samples submitted to experts for grading were rated as worth 37 to 39 cents per pound.

In cooperation with the insular government a commercial planting of Sea-island cotton has been made and a roller gin purchased. Besides teaching better methods in growing, it is hoped to develop better means of preparing and marketing cotton in Porto Rico.

Of the introduced fibers sisal is promising as a money crop. The Panama-hat palm is now grown in several sections, and the weavers are begining to use the fiber. Ramie grows well at the station and might be taken up could suitable machinery be devised for its economical extraction.

## COOPERATION.

The station has a number of cooperative projects under way, as follows: With the insular government in growing fiber crops; with the United States Department of Agriculture in the introduction of economic seeds and plants; with a number of planters in fertilizer trials on various soil types, in soil disinfection, in testing new seedling canes, in animal cross breeding, and in the dissemination of parasites of insects.

## RUBBER.

Many inquiries are received by the station as to the suitability of Porto Rico as a rubber-producing country. Our experiments have not yet gone far enough to draw definite conclusions, but it does not appear that the island will enter to any extent into this industry.

Although some varieties of rubber-producing trees have grown well at the station, their extended planting can not be advised. Doubtless on many farms there are areas where trials might be made to employ

profitably what is otherwise waste land. As a commercial proposition rubber can not at present be recommended, for the following reasons: The yields of rubber per tree are low, lower in fact than most of the literature on rubber would lead one to believe; lands are too high in value to undertake rubber growing; Porto Rico is close to and has free entrance to the best market in the world, and the most profitable products to grow are either those that are favored by a protective duty or that are of such a perishable nature as to prohibit competition from more distant lands. Again, the rubber industry is highly speculative. When the raw product will double in price in a year and fall again to less than half, it is very evident that its profitable production is highly unstable. Moreover, cultivated rubber must compete with wild rubber, the extent and cost of which is very difficult to estimate.

## PROPAGANDA.

The success of the work of an experiment station must necessarily depend in large measure upon the adoption of the results by the people for whose benefit the experiments are made. Although more interest is manifested each year by the people of Porto Rico in improved agriculture, yet the station feels handicapped by not being able to make a more active campaign in extension work. This lack the agricultural college will fill in time. Also it seems likely that an insular bureau of agriculture will be established. Such is highly desirable and the time is ripe. While the island has been much improved in the way of roads and buildings, made possible by increased revenues, but a small portion of the revenue has been directly applied to improve the industry which makes them possible.

The correspondence of the station has grown enormously and much information has been disseminated by letter as well as by published bulletins and reports.

Considerable traveling has been done by the several members of the station staff throughout the various agricultural sections of the island. Means of transportation are improving each year, but much is yet to be desired. While the area of Porto Rico is limited, being about 100 miles long by 40 miles wide, yet owing to the broken nature of the surface travel is tedious and expensive.

During the summer a six weeks' school of instruction held at the station was attended by over 100 persons. This session was of an entirely practical nature, and was held for the object of stimulating an interest in improved agriculture such as would lead to its more extended study and application. Several conferences with displays of agricultural products and methods were held during the year. These conferences were largely attended and much enthusiasm was shown.

## STATION WORK.

The work of the station is limited only by its income. The present needs are great because of the wide and unexplored field of tropical agriculture and the limited number of persons engaged in this branch of agricultural science.

Continued efforts have been made to direct the work into more definite lines, especially those relating to tropical conditions. Especial attention is given to soils. With a climate of continuous summer and a bountiful rainfall the production of crops in the Tropics would seem to require only a reasonable tillage, but such does not always produce the expected results. The solution of the question resides in the soil. In the Temperate Zone after the freezing and thawing of winter, soils seem in better condition to produce a crop. In the Tropics, where such conditions do not obtain, soils seem less responsive at a definite season of the year. It seems, however, that after lying fallow, or following a drought when the soil has become thoroughly dried, the growth of plants is usually much more active. Soils burned over become much more responsive and plants grown in such areas soon outstrip others where no burning has taken place. Again, it is found that certain disinfectants render tropical soils more productive, although they add nothing directly in the way of fertility. Tropical soils are filled with many bacteria, some of which, notably certain anaerobic forms, are detrimental to the best growth of plants.

The work in medical science in the last decade has rendered the Tropics habitable to northern races, and has undoubtedly paved the way for the migration into this region which has already set in. Agricultural science is also destined to render this region, naturally favorable in many ways to man's comfort and happiness, the most prosperous section of the world.

## REPORT OF THE PHYSIOLOGIST.

By Oscar Loew.

### ARE PROTOZOA CONCERNED IN SOIL SICKNESS?

The existence and general occurrence of protozoa in soils is but a recent observation. When soils are examined under the microscope, it is a difficult matter to discover them, but as soon as a suitable nutrient solution is added to soil, the protozoa will multiply by feeding upon the soil microbes and can then be easily seen in every drop of the liquid. Probably the infusoria are periodically encysted in soils, especially in dry seasons, and develop afresh as soon as water and organic matter bring on an increase of microbes.[1]

When cultures are made in the usual way for Azotobacter in soils, a most favorable development of protozoa takes place also, especially of infurosia, and to a less extent of amœbæ and flagellatæ, all feeding upon the cells of Azotobacter. Azotobacter occurs not only in the surface soils of arable land but also in sand dunes, as was found in examining one of a North Sea island (Borkum); there was also present at least one kind of infusoria. It was not suspected that such a loose sandy soil, not organically manured and almost free from calcium carbonate, would contain Azotobacter.[2] This organism, often accompanied by the butyric bacillus, was also observed upon leaves in Porto Rico, while in Temperate Zones Azotobacter was not found upon leaves.

For sake of convenience the test for both Azotobacter and protozoa may be mentioned here. A conical flask of about 100 cubic centimeters capacity, provided with a cotton plug and containing 15 to 20 cubic centimeters glucose nutrient solution, free from nitrogen compounds, and 5 grams calcium carbonate, is sterilized and then about 10 grams of the carefully collected soil is added. After shaking well the mixture is left at 16° to 25° C., protected against the direct rays of the sun for one to three weeks. The glucose nutrient solu-

[1] It was observed more than 30 years ago by Nageli that the microbes are the main food of infusoria. He attributed to this circumstance the limitation of bacterial growth in polluted waters. The writer has observed vinegar eels feeding upon bacteria and certain aphids subsisting on the spores of mold fungi.

[2] The dune from which the sample of soil was taken at a depth of 5 to 6 centimeters was neither close to the seashore nor to cultivated land. It was moderately covered by a growth of *Rubus fruticosus* and Rhododendron. The film of Azotobacter developing after three weeks standing of the test flasks, was of faint brownish color; the cells—mostly "diplococci"—appeared to be smaller than those of the widespread kind, *Azotobacter chroococcum*.

tion mentioned contains 1 per cent glucose, 0.2 per cent monopotassium phosphate, and 0.02 per cent magnesium sulphate. A film of Azotobacter cells, gradually turning brownish, will appear, accompanied by various other microbes and by protozoa.

It may sometimes happen that soil of a certain depth in which Azotobacter is absent is to be tested for protozoa. In such a case an inoculation of the soil with a pure culture of Azotobacter would be the simplest way to provide food for the development of protozoa in the test flask.

Now, observing the eagerness of the protozoa in devouring the cells of Azotobacter, the inference might easily be reached that the protozoa can cause injury to soils by decimating or reducing the number of useful microbes, which enrich the soil with nitrogen compounds or cause the formation of humus, or produce ammonia from combined nitrogen compounds. A. D. Hall,[1] of the Rothamsted Experiment Station, has recently suggested the theory that protozoa in the soil act injuriously by preying upon bacteria that transform organic nitrogen compounds into ammonia, thereby rendering them available. An increase of ammonia had been observed by Russell and Hutchinson in soils that had been treated with disinfectants. But in the paper at hand it was not stated whether the increase of ammonia was observed immediately after treatment or after several days, when the number of microbes had been again on the increase. Nor was it stated whether all protozoa were really killed by the disinfectant; encysted infusoria may be resistant. If an increase of ammonia was observed immediately after disinfection another explanation than that of Hall may be possible.[2] Heinze as well as Pickering[3] had already observed an increase of soluble organic matter in the soil after treatment with antiseptics.

How far the protozoa are concerned in the "tired" condition of soils can be properly estimated only when their relative number in different soil strata to a depth of 1 meter have been determined and when it has been definitely determined to what degree the multiplication of microbes is kept down by the voracity of these organisms.

Soils with restricted aeration, as clay soils and stiff loam soils, will probably show protozoa only on and near the surface, since the bacteria in the deeper strata will soon render the limited store of air unfit for the respiration of protozoa. Clay soils especially often show a sick condition of a peculiar order. Neither parasitic mi-

[1] Address to the Agricultural Subsection of the British Association for the Advancement of Science, Sheffield, 1910. Published in Science, 32 (1910), No. 820, p. 363. The writer had published in Science, 31 (1910), No. 808, p. 988, a note on soil bacteria in the Tropics, stating among other things that "Infusoria, flagellatæ, and amœbæ devour great numbers of microbes."

[2] Hall's discussion was based upon investigations by Russell and Hutchinson, reported in full in Jour. Agr. Sci., 3 (1909), No. 2, p. 111 (E. S. R., 22, p. 121).

[3] Cf. Porto Rico Sta. Circ. 11, pp. 6, 7.

crobes, fungi, or organisms such as nematodes can be found in many such cases. This may be attributed to two causes—either the total number of microbes have so far increased as to cause suffocation or the number of certain injurious microbes of fermentation and reduction have reached an unhealthy increase. The observations of the writer convinced him that both these causes can occur.

In loose soils no doubt injurious organisms, which need not be of the parasitic class, can also cause a "tired" condition by eating away the fine roots and root hairs. There might even exist injurious nematodes of a nonparasitic nature. A careful examination on these points must settle the question.

The theory of Hall may no doubt be correct in special cases; it is only the generalization of it which does not seem admissible. The numerous protozoa which are observed when soils are kept for a few days in a nutrient solution are the result of much more rapid multiplication than takes place in the soil under usual conditions, and hence their relative number might be overrated.

The beneficial action of certain kinds of microbes is doubtless an important factor, but in view of these useful effects[1] it is often forgotten to consider the opposite side. There doubtless also exist various harmful organisms among the soil bacteria, nonparasitic and parasitic.

## A COMPARISON OF SOIL DISINFECTANTS.

Since the question of the cheapest and most effective way of disinfecting a sick soil is of practical importance, the following experiment was carried out in soil where lilies had suffered for a series of years, as shown by the decreased flower production, yellowed leaves, and degenerate and more or less rotten bulbs. True parasites were absent, but aphids were noticed in the adhering earth; their number, however, was too small to be considered seriously. Desulphurization microbes and butyric fermentation bacilli were adhering to the roots and to rotten parts of the bulbs to a great extent. Two grams adhering soil[2] produced in five days at 30° to 34° C. 12.5 cubic centimeters gas (carbonic acid and hydrogen) and 0.038 gram butyric acid (with some acetic acid). A piece of root of 0.7 gram, fresh weight, yielded, with 100 cubic centimeters of nitrogen, free glucose-culture solution in absence of air at 30° to 34° C. after five days an intense butyric fermentation, and titration showed a content of 0.246 gram butyric acid.

[1] That under certain conditions bacteria are entirely superfluous in the soil is not only shown by the success of sand cultures, but also by the full plant development on soils almost devoid of organic matter and free of microbes, as has been observed at this station with a soil of 6 meters depth.

[2] The soil was a coarse, sandy soil, poor in clay and humus. When heated in a test tube, vapors of a strongly alkaline reaction and empyreumatic odor were developed.

The lily beds were divided into five plats, each measuring 1.5 meters in length and 1 meter in width.

A received 100 grams chlorid of lime, dissolved in 5 liters of water, administered partly in holes and partly on the surface.

B received 110 grams potassium permanganate, dissolved in 10 liters in the same way.

C received 30 grams tricresol in 5 liters of water.

D received 250 cubic centimeters bisulphid of carbon in 5 holes, which were closed at once and then water poured on top.

Six weeks later, April 8, each plat received six, about equally large, potted cultures of three to four healthy bulbs of *Lilium candidum*, which cultures had leaves from 21 to 24 centimeters in length and were planted with the adhering earth. Gradually bud-bearing stems developed from some of the cultures, and on June 6 the conditions were as follows:

*Effect of soil treatment on flower-stalk development.*

| Plats. | Number of bud-bearing stems. | Number of flower buds. | Average height of stems. |
|---|---|---|---|
| | | | *Cm.* |
| Check | 4 | 18 | 69.0 |
| Chlorid of lime | 8 | 55 | 90.0 |
| Potassium permanganate | 6 | 31 | 65.3 |
| Tricresol | 7 | 39 | 62.5 |
| Bisulphid of carbon | 5 | 35 | 67.1 |

The plat with chlorid of lime produced the most flowers.

On viewing the plants in autumn the development of new leaves from the bulbs on plats treated with the tricresol and bisulphid was noticed to be far in excess of those on the other plats. When harvested, October 22, it was noticed that the bulbs in the control plat were of insufficient cohesion, the outer shells often in brown and rotten condition and breaking off easily; next in quality were those of the tricresol bed. Most of the bulbs in the other plats were of firm texture and perfectly healthy, and in the bisulphid of carbon plat especially they had grown to a considerable size. In all plats the young bulbs were few in number; only 2 were found in the bisulphid and tricresol plats, 4 with permanganate, 7 with chlorid of lime, and, strangely enough, 10 on the check plat. It appeared that the unfavorable condition of the old bulbs on this plat had promoted new formations. The further determinations are seen from the following table:

*Effect of soil treatment on growth of lilies.*

| Plats. | Average weight of one bulb. | Fresh weight of leaves of total crop. |
|---|---|---|
| | *Grams.* | *Per cent.* |
| Check | 42.8 | 13.8 |
| Chlorid of lime | 47.0 | 12.8 |
| Permanganate | 51.1 | 10.6 |
| Tricresol | 57.9 | 18.2 |
| Bisulphid of carbon | 53.9 | 20.9 |

It will be noticed that the chlorid of lime plat which produced most flowers was behind in the growth of old bulbs, a correlation due to a certain exhaustion. The comparatively greater production of leaves on the bisulphid plat indicates that there had been an increase of available soil nitrogen.

Since flowers and seed formation were most increased by chlorid of lime, this must be considered as the most favorable and cheapest disinfectant in this case. Chlorid of lime has apparently thus far never been used in soil disinfection, and this case as well as some other experiments of this station are the first in this line.

## REPORT OF THE CHEMIST.

By P. L. Gile.

### INTRODUCTION.

The work carried on since the last report has been of the same character as that of previous years. Miscellaneous routine analyses have been performed, an investigation on pineapple soils commenced in 1908 has been completed, and satisfactory progress has been made in several other investigations on soils and plant nutrition.

Laboratory facilities have been improved by the addition of a room and by the purchase of a new balance, extraction apparatus, and a vacuum drying oven.

### SUMMARY OF THE WORK.

The analytical work has consisted of the analysis of 290 samples of sugar canes, molasses, waters, limestones, soils, plant ashes, stable manures, bat guanos, and commercial fertilizers. Also, many qualitative examinations have been made of ores, fertilizing materials, and soils sent to the laboratory for information.

The investigations now in progress are on soil disinfection; the availability of the nitrogen and phosphoric acid in bat guanos; the effect of strongly calcareous soils on the growth and composition of various plants; the cause and correction of lime chlorosis; the effect of various ratios of calcium and magnesium chlorid on rice.

### PINEAPPLE SOILS.

This investigation, begun in 1908, was for the purpose of discovering the cause of the failure of the pineapple crop on certain soils where the plants presented a peculiar bleached or chlorotic appearance. Since the mention of this trouble in the last report many new cases have been found in different parts of the island, and it is apparent that the soil condition causing it is more widespread than was at first suspected. The detailed results of the investigation are being prepared for publication, but brief mention is here made of some of the more important facts.

The bleaching or chlorosis of the plants is a result of malnutrition caused by the excessive amount of calcium carbonate contained in the soils. It appears that a content of more than 2 per cent of calcium carbonate renders ordinary soils unsuited for pineapples. Soils with an exceptionally high content of organic matter, such as occur in the Florida Keys, are suited for pineapples in spite of a high content of calcium carbonate. No soil of this character, however, to our knowledge, exists in Porto Rico. Soils containing much calcium carbonate

are alkaline in reaction, but it is not the mere alkalinity that induces the chlorosis.

Treatment of chlorotic plants with ferrous sulphate has resulted in restoring the normal green to the leaves and in stimulating the growth. It is doubtful if this treatment, however, would make plantings on such soils commercially profitable. Treatment with fertilizers is not effective in curing the chlorosis.

These soils can be profitably planted with many other crops; lime-loving plants such as tobacco, coconuts, and gandules do well.

Some facts and analytical results which are not connected with the above lines of investigation and will not be published elsewhere are mentioned here.

## A CALCAREOUS HARDPAN.

A peculiar soil condition occurring in a citrus grove 3 miles west of Bayamon, P. R., came to our notice during the past year. This plantation consists of about 200 acres of 10-year-old grapefruit and orange trees. Since the establishment of the plantation many trees have died in certain of the groves, apparently from unfavorable soil conditions.

Just previous to setting out the plantation the land was covered with a heavy forest growth of large trees. The surface soil is a rather fine sand and in most parts is rich enough in humus and organic matter to have a loamy character. The chemical composition of the surface soil varies considerably in respect to the content of lime, some areas containing less than 1 per cent and others containing 10 to 15 per cent. Sample No. 221 is the surface soil from one of the groves and No. 220 is the subsoil.

*Analyses of soils from citrus grove.*

| Constituents. | No. 221. | No. 220. |
|---|---|---|
| | *Per cent.* | *Per cent.* |
| Insoluble residue | 70.09 | 61.59 |
| Potash ($K_2O$) | .18 | .09 |
| Lime (CaO) | 5.40 | 13.93 |
| Magnesia (MgO) | .17 | .80 |
| Ferric oxid and alumina ($Fe_2O_3$ and $Al_2O_3$) | 12.45 | 9.56 |
| Phosphorus pentoxid ($P_2O_5$) | .13 | .09 |
| Loss on ignition | 10.94 | 13.11 |
| Total | 99.36 | 99.17 |
| Nitrogen (N) | .31 | .03 |
| Moisture | 2.21 | .65 |
| Reaction to litmus | Alkaline. | Alkaline. |

The alkaline reaction is due to calcium carbonate, as no water-soluble alkalis were found present.

At a depth which varies from 2 to 8 feet a stratum of impervious red clay or hardpan is encountered. In spots where many trees have succumbed the sand lying some distance above the clay hardpan and below the surface soil is of a cementlike character. Dead trees show the roots embedded in this mass as though set in cement.

In one grove of some 40 acres on this plantation about 40 per cent of the trees have succumbed at various times. In this grove the layer of rocklike sand lies from 6 to 18 inches below the surface and is about 18 inches thick. Between the cemented sand and the clay hardpan loose sandy soil occurs. On crumbling this rocklike material it is seen to be composed of essentially the same soil particles as occur in the loose soil above and below it. From the proximity of the land to the sea it was thought probable that alkaline salts might play some part in cementing the soil particles together. Accordingly the water of a well located in the field was analyzed as well as a water solution of the substance. The water solution showed that no appreciable quantities of any soluble salt were contained in the material. The analysis of the well water was also low in alkaline salts.

On treating a sample of the cemented soil with dilute hydrochloric acid and observing the action under the microscope it was apparent that the soil particles were bound together by calcium carbonate. Particles of quartz and other minerals were seen to be connected and, in some cases, coated by a thin layer of calcium carbonate. This sandy cement may then be termed a calcareous hardpan.

From the observations of the manager this calcareous hardpan apparently forms rather quickly in spots. That it was not always present like the clay hardpan is evidenced from the occurrence of loose sandy soil above and below. The occurrence is probably to be explained somewhat as follows:

The underground soil water which, in certain times, is to be found on the layer of clay hardpan, becomes charged with carbon dioxid and so dissolves the calcium carbonate contained in the soil. As the soil water rises by capillarity it carries calcium carbonate held in solution by the carbon dioxid. As this solution nears the surface, carbon dioxid escaping and water evaporating, calcium carbonate is deposited between the soil particles, cementing them together.

Certain observations lent credence to this view. Several pieces of the hardpan were found in which there were small cracks or fissures. These cracks were lined with a continuous white layer of calcium carbonate. Under soil conditions, such as the presence of much humus, which would keep the soil loose and diminish the rise of underground water, the hardpan did not approach so near the surface.

To combat the formation of this calcareous hardpan probably the most effective measure would be good drainage on a level with the stratum of impervious clay. The addition of organic matter, and any treatment which will tend to check the rise of underground water or prevent the accumulation of water on the clay hardpan should prove beneficial.[1]

[1] This condition is similar to that described by Hilgard (Soils, p. 162), except that here the effect is evidently due to the rise of soil water.

## MISCELLANEOUS FERTILIZERS.

Analyses of various fertilizing materials, which have been made from time to time, are given below. The results are all calculated on the moisture-containing substance.

*Analyses of fertilizing materials.*

| Materials. | Nitrogen (N). | Phosphoric acid ($P_2O_5$). | Potash ($K_2O$). | Moisture. |
|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Goat manure | 2.32 | 0.47 | 3.72 | 37.48 |
| Do | 1.92 | .76 | 3.01 | 20.77 |
| Sheep manure | 1.26 | .59 | 2.54 | 39.66 |
| Seaweed | 1.18 | .16 | .93 | 19.22 |
| Cachasa (filter press residue) | .75 | 2.02 | ..... | 63.49 |

The advisability of using such fertilizing materials as the above depends upon their cost laid down on the place where they are to be applied. It should be borne in mind that it is so much nitrogen, potash, and phosphoric acid that is desired, and not the total bulk of the fertilizer. The cachasa is a waste product of sugar mills. In the dry state it should be worth, roughly, $12 a ton. In the state in which it is thrown out from the mill, two-thirds of the content being water, it is worth about $4 per ton.

## ANALYSES OF LIMESTONES.

The composition of various samples of limestones, burnt lime, and marl from different parts of the island are given here. The following are samples of burnt lime. As these were sent to us in small packages, they were partially air slaked when analyzed. They are to be judged, then, on the amount of impurities they contain rather than on the percentage of CaO. The results are calculated on the moisture-free material:

*Analyses of samples of burnt lime.*

| Locality where sample taken. | Silica ($SiO_2$). | Iron and alumina ($Fe_2O_3$ $Al_2O_3$). | Lime (CaO). | Magnesia (MgO). | Loss on ignition. | Total. |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | |
| Guanica | 0.12 | 0.20 | 68.45 | Trace. | 31.23 | 100.00 |
| Tallaboa | .70 | .48 | 67.38 | .90 | 30.31 | 99.77 |
| Cabo Rojo | 1.35 | 1.21 | 70.18 | 2.23 | 25.11 | 100.08 |

It will be seen that the sample from Guanica is exceptionally pure, that from Tallaboa is also very good, and that from Cabo Rojo contains more impurities.

The following are analyses of disintegrated natural limestones. The results are calculated on the moisture-free material.

*Analyses of samples of disintegrated limestones.*

| Locality where sample taken. | Silica, sand, and clay ($SiO_2$). | Iron and alumina ($Fe_2O_3$ $Al_2O_3$). | Lime (CaO). | Magnesia (MgO). | Loss on ignition. | Total. |
|---|---|---|---|---|---|---|
| | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* | *Per cent.* |
| Quebradillas | 1.29 | 0.82 | 34.89 | 16.68 | 46.23 | 100.01 |
| Do | .49 | .51 | 34.76 | 18.17 | 46.57 | 100.40 |
| Do | .20 | .68 | 49.82 | 4.86 | 44.32 | 99.88 |
| Pueblo Viejo | ..... | ..... | 48.74 | ..... | ..... | ..... |
| Do | 38.32 | 4.08 | 29.39 | Trace. | 28.53 | 100.32 |
| Arecibo | 3.29 | 1.15 | 53.36 | Trace. | 42.20 | 100.00 |
| Bayamon | 51.69 | 3.92 | 21.66 | Trace. | 22.24 | 99.51 |
| Tallaboa | 8.41 | 1.90 | 50.76 | .84 | 38 81 | 100.72 |

These limestones are all as finely disintegrated as an ordinary soil and may be utilized for liming acid soils. Two of the samples contain such a large amount of sand and silica that they are of no value except to persons in the immediate vicinity of the deposits. The samples from Quebradillas contain much magnesia.

For correcting acid conditions one part of burnt lime probably has an action equivalent to five or six of a natural limestone, such as the above. This is merely an estimate based on the following points: Burnt lime, weight for weight, contains two times as much lime (CaO) as a natural limestone; burnt lime is more finely divided than these limestones; the action of the calcium oxid (CaO) of burnt lime is much more energetic than the action of the calcium carbonate ($CaCO_3$) of the natural product. The use of the natural, disintegrated limestone has the advantage that there is little danger from overliming.

The increased yields resulting from liming our acid clay soils renders the utilization of these deposits highly advisable. An acid clay soil of the station planted to sugar cane was much improved by liming. The data of this experiment follow.

There were five plats of one-twentieth of an acre each. The check plat received no lime nor fertilizer, one received 25 pounds of air-slaked lime, another 25 pounds of lime plus a complete fertilizer, another 150 pounds of lime, and the last 150 pounds of lime plus a complete fertilizer. The variety of cane planted was B1753. The yield of cane, calculated as tons per acre, was as follows:

*Effect of lime on cane production.*

| Treatment of plats, rate per acre. | Cane per acre. |
|---|---|
| | *Tons.* |
| Check, nothing added | 44.0 |
| 500 pounds lime | 50.2 |
| 500 pounds lime and fertilizer | 57.3 |
| 3,000 pounds lime | 69.3 |
| 3,000 pounds lime and fertilizer | 61.6 |

## REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

### CITRUS FRUITS.

The progress of the citrus industry for the past year has been very satisfactory. With the better understanding of cultural methods and a realization of the value of windbreaks the quality of the fruit produced is much superior to that of a year ago. A number of orchards just coming into bearing have yielded good returns. Some groves of 4-year-old grapefruit trees, having made a good growth, bore a crop of fancy fruit. Shipping of the native oranges which grow wild through the western part of the island did not begin this year until the fruit was in saleable condition, and during the early part of the season the fruit sold well, being recognized by the good buyers and selling along with the cultivated varieties. When the market returns showed good profits numerous unscrupulous shippers began exporting fruit which was too green for consumption and which had been so roughly handled that it reached the market in very poor condition. Such sales resulted in a great injury to the market for Porto Rican fruit. The same is the case almost yearly. If shipping of green and carelessly handled fruit could be prevented by law, it would be a great benefit to the fruit industry of the island.

Such a large amount of the uncultivated fruit decayed in transit to New York that an experiment to determine the percentage of damage due to injured fruits was made. The work was carried on in the packing house of the R. S. Hammond Fruit Co., who kindly furnished the fruit for the experiment. As it was late in the spring when the test was made the fruit was very ripe and had been badly injured in picking and hauling. The following classes of fruit were wrapped, packed, and stored in a room where the temperature ranged from 80° to 84° F.: One crate of fruit that had been bruised in bringing from the field, one crate of stemless but otherwise soud fruit, one crate of sound fruit, and one crate of fruits that had been pricked or clipper cut. At the end of 14 days the fruit was examined and the following notes were made: Of the box of bruised fruit 22 per cent had decayed, of the stemless 11 per cent, of the sound fruit 5 per cent, and of the pricked or clipper cut 38 per cent. Each decayed fruit was found infected with blue mold. This shows that here, as else-

where, the main cause for the decay of citrus fruits is careless handling.

Fruit in a number of orchards ripened out of season this year, all of which brought a high price. As the summer and winter temperatures in Porto Rico vary so little it seems that at least in sections where the rainfall is well distributed throughout the year citrus trees may be brought into bearing either before or after the main crop has been shipped from California and Florida. Some experiments to determine the influence of fertilizers in this respect are under way both at the station and among the planters. (Pl. I, fig. 1.)

The fertilizer experiments that have been carried on for the past few years in cooperation with planters are being continued. The complete fertilizers are giving the best results again this year.

During the last year an orchard survey of the island was undertaken and is being carried forward as fast as possible.

From the planting of orange varieties the following notes have been taken: Fruit from the variety Early Oblong is this year of a very fair quality and flavor and of good appearance, while last year it was very irregular in shape, poor in texture, and of a very undesirable flavor. These trees are now 5 years old and bore their first crop last year. Selected native seedlings have made a more thrifty, upright growth than the imported varieties, and this year 5-year-old trees are bearing a fair crop of fruit. The tall growth is objectionable, as the tree tops are more exposed to winds and the picking of the fruit is more difficult. Hart Late has succeeded much better than any of the other varieties at the station. These trees, while bearing a heavy crop, remained very vigorous through the long and severe drought of last winter, and during the past summer they have shown no detrimental effects from the excessive rains. Rangpur limes, which ripened in December, 1909, were left on the tree and are in good condition one year later. A number of less commonly imported citrus types have fruited this year, none of which gives promise of being of interest commercially.

## COVER CROPS.

The practice of growing cover crops at least during the season when the frequent rains prevent cultivation and on soils which wash badly is practiced quite generally in Porto Rico. Work to determine the best leguminous plants for this use is being continued. During the past year plantings were made of cowpeas, velvet beans, quar, crotalarias, a native species of Phaseolus, a cassia, lablabs, pigeon peas, and various native legumes. One planting of the above crops was made late in March on a sloping, very heavy, poorly drained soil. The rains were so frequent that no cultivation was attempted

FIG. 1.—FERTILIZER EXPERIMENTS WITH ORANGES.

FIG. 2.—TOP-WORKED MANGO TREE.

FIG. 1.—BARK-GRAFTED MANGO.

FIG. 2.—EUCALYPTUS PIPERITA AND E. ROBUSTA, 2 YEARS OLD.

after the first few weeks of growth. Under these conditions, both the Clay and Whippoorwill varieties of cowpeas did well, they being the first to cover the ground. This crop produces a good amount of vegetable matter, but matures in midsummer, which allows grass and weeds to grow during the remainder of the rainy season. The velvet beans did not cover the ground as quickly as the cowpeas or canavalias though they made a heavy growth and kept down all objectionable vegetation until late in the fall. The pigeon pea grew rapidly, reaching 8 feet in height. This plant, while not covering the ground as well as other crops, produces a good quantity of vegetable matter and is an excellent windbreak when planted near young trees. *Canavalia gladiata* made the most rapid and vigorous growth of any of the crops. It covered the ground in a few weeks after planting and smothered all grass and weeds. This plant continues its vigorous development until checked by the drought of the winter. Its extensive root system with its heavy top growth makes it valuable for lands injured by washing, though its vining habit is often troublesome in an orchard. The growth of the other legumes did not indicate that they would be of value as cover crops under the conditions, but they will be tested further. A planting has been made to test these crops during the winter months. Though the weather conditions have been good the plants have made a very poor start for these first two months, the velvet bean making the most satisfactory growth.

## MANGOES.

Sixteen varieties and 21 seedling types have been added to our variety planting during the past year. With these additions the station now has growing 62 varieties, besides the numerous seedling types. Of the varieties set in 1904 and 1905, Sandersha, Ameeri, Cambodiana, Mulgoba, Totafari, Bulbulchasm, and Mulgoa fruited this year, this being the first crop for the last four. Sandersha was the most prolific variety, single trees bearing from 60 to 190 large fruits. Cambodiana and Bulbulchasm were considered the best in flavor. The fruit flies, which ruin all fruits of some types of native mangoes, injured many fruits of the variety Cambodiana and a few of those of Sandersha when they were allowed to ripen on the tree. This fly is such a serious pest that varieties attacked by it can not be recommended until a means for its control has been found.

Experiments in propagation have been continued, including inarching, budding, bark grafting, and growing seedlings from various superior fruits. (Pl. I, fig. 2.) Bark grafting both young and old trees gave good results, and at least for old trees this method seems to be most satisfactory. (Pl. II, fig. 1.)

The fruits from the varieties Sandersha, Ameeri, and Cambodiana were used in experiments to test the time for picking, methods of

packing, and keeping quality. Fruit representing three stages of ripeness was gathered and stored in rooms of different temperatures. In one room the temperature ranged from 42° to 48° F. and in the other from 80° to 83°. Some of the results noted are as follows: A fungus disease which attacks the skins of some varieties injured many of the Ameeri and Sandersha fruits in the warm room, they having probably been infected in the field. This disease did not affect the fruits of Cambodiana or other varieties in the cold room. Fruits almost ripe when picked softened within a few days in the warm room, the softening in the cold room being very much slower. Fruits of the three varieties picked, while still solid, though mature, ripened in from 10 days to 2 weeks in the warm room, whereas those in the cold room remained unchanged for 60 days, so far as could be observed. Fruits wrapped in oil paper ripened more slowly, and those infected with disease did not decay so rapidly.

### AVOCADOS.

With the avocado trees set in the upland orchard where the soil is a heavy clay that drains very poorly there has been trouble for a number of years from the trees dying. A number of imported kinds of avocados were set out, but during the past summer the last of them died. The trees do well until 3 or 4 years old, when growth ceases, in some cases the trees dying in a very few months, while others live on for a year or more. The trouble with these trees seems to be wholly a matter of soil conditions. On removing a dying tree it was found that the roots, which had gone down 8 or 9 inches or more, were badly decayed, resulting no doubt from the excessive moisture in the soil. The months of dry weather last winter so dried the few inches of surface soil that the roots in this region were starved. Fortunately this soil condition does not prevail generally. Within a short distance from the experiment station in more open soils avocados flourish and produce excellent fruits.

Growing avocados commercially seems to be an industry which has been neglected in Porto Rico, though there seems to be no serious hindrance to growing the fruit for shipment to the cities in the United States. Our native trees produce well without the slightest attention, and, as the fruiting season lasts for months, it seems that the avocado could be produced at a good profit on soil suited to its growth.

### TEMPERATE-CLIMATE FRUITS.

These fruits were represented in the station orchard by pears, peaches, plums, apples, and persimmons. A few varieties of each of these fruits were still living, but the poor growth proved them worthless and they were removed. The soil in which these trees were grow-

ing is the same as that described in the notes on avocados and its influence on the roots was the same, but the roots of these fruits withstood the drought better. Except for a few poorly developed peaches of the Peen-to and Red Ceylon varieties and a very few from the Burbank plum no fruits were borne. During the last year the trees became less thrifty than they had formerly been.

## VEGETABLES.

The experimental work of the past year with vegetables is being continued, including variety and cultural tests with yams, malanga, and yautias; a variety and fertilizer test with watermelons and cantaloups; breeding of various garden crops; a study of the degenerating influence of the climate on some introduced garden crops, etc.

The severe drought that continued for months during the winter of 1909–10 and the lack of irrigation facilities prevented most of the vegetables from making a satisfactory growth. Good results have been obtained in the experiments with yams and malangas, and this work is being continued and others are being started. Where a heavy application of stable manure was made the few varieties of melons in the fertilizer experiments did well, while all of those which received little or no manure died except a type of native cantaloups. This plant showed little effect due to the fertilizers, remaining thrifty for a number of weeks after the plants of the imported varieties had died, both in the check and chemically fertilized plats. Though it did not rain after the melon vines were a few inches in length, both varieties of watermelons—Southern Rattlesnake and Cuban Queen—planted in hills which had been given a heavy application of manure, bore a fair crop of excellent melons, single fruits of Cuban Queen weighing 30 pounds and averaging 18 pounds, those of the other variety weighing somewhat less.

## MISCELLANEOUS PLANTS.

Types of *Carica papaya*, including natives, those from Hawaii and from the United States Department of Agriculture, Bureau of Plant Industry, have fruited here this year. The types from Hawaii made somewhat the best growth and produced fruit superior to that of the others, but were not so prolific as the native Porto Rican plants. A fly did great damage to the fruit, leaving but few uninjured. This, together with other insects and an unsuitable soil, resulted in an unsatisfactory growth of these plants. Work with these fruits will be carried on another year.

Cuttings of 55 varieties of grapes, including American, European, and hybrid varieties, were received mostly through the Bureau of

Plant Industry of the United States Department of Agriculture. When the cuttings had made sufficient growth they were removed to the field, where most of them have since died. None made a satisfactory growth. This is no doubt due to the unfavorable soil condition, as thrifty vines are found in various places over the island.

The present plantings of Eucalyptus are confined almost entirely to the flat, poorly drained soils, under which conditions the various varieties show considerable difference in thriftiness. *E. piperita* and *E. robusta* have made the best growth. *E. robusta* trees two years from planting are 29 feet tall, having grown 13 feet during the past 12 months. (Pl. II, fig. 2.) *E. piperita* has grown slightly faster. These varieties, as well as all others under observation, have made much slower growth on one side of the field, where the drainage is somewhat poorer than on the other.

Experiments with seed beds, transplanting, etc., are being continued.

## REPORT OF THE ENTOMOLOGIST.

By W. V. Tower.

During the past fiscal year a number of new entomological problems have been taken up, among them the study of an injurious ant found in coffee and one of its shade trees, the guama, and of various insects injurious to the guava.

Much time has been devoted to the study of the Lachnosterna beetle found in the cane fields. Many fields have been visited from time to time, and a great number of cooperative experiments have been carried on during the past season. Many valuable data have been brought together regarding the life history, periods of flight in different sections of the island, food plants of adults and of the larva, and conditions most attractive to the laying adult.

Many experiments have been made to combat the grub and the beetle. A parasitic mite has been found on the larvæ, and its work is being watched with great interest.

### GUAVA INSECTS.

There seems to be an unusual number of insects which attack the guava; among them are leaf eaters, fruit curculios, fruit flies, and scale insects. The most destructive insects to the crop are the fruit flies and two beetles which pass their larval period in the growing fruit; one is a large beetle which develops in the blossom, using the flower as its food; the other passes its larval period in fruits ranging in size from $\frac{1}{4}$ to $1\frac{1}{4}$ inches in diameter. Most of the fruits in which these insects have been found have become black and mummified. Hundreds of mummified fruits have been examined, and a very high per cent contain the larvæ of a small snout beetle, or the fruit shows that it has been eaten by it. The larva bores into the dried, fleshy part of the fruit and also into the flesh surrounding the seeds. The fruits are stung when they are small and still green.

The guava-fruit fly in Porto Rico is very destructive, and practically all the ripe fruits are infested with this pest. This insect is being studied, and it is hoped to find a period in its life history when it can be successfully destroyed. The eggs are laid when the fruits are still green, and when they are dead ripe the larvæ are ready to pass to the ground, where they pupate. The larvæ destroy the fleshy parts of the fruits and are also found feeding on fleshy matter between the seeds.

## COFFEE INSECTS.

An ant has been causing a great deal of trouble in coffee and coffee-shade trees during the past year. Although no remedy has been found, many interesting points have been observed concerning its habits and food supply. The ants live in the coffee-shade trees principally, but some colonies have been observed in the coffee itself. They obtain their food from the honeydew secreted by two species of scale, one the common mealy bug and the other a very large, fleshy scale, pinkish in color. The scales are often kept in the canals which are cut by the ant in small branches and twigs of the shade trees and also in the coffee trees. They also carry the young of the scale and deposit them on the leaves; this has been noted on coffee which has been under observation in the laboratory.

These insects seem to prefer the guama shade tree as their host plant, but are also found living on the ground in the dry twigs of coffee and guama. Experiments with tanglefoot and with repellents have been tried, with varying results.

## CITRUS FRUITS.

Experiments in the fumigation of citrus trees were carried on during the year. The percentage of dead insects found on trees after fumigation was very great, only 0.5 per cent being alive. The object of the work was to compare results of fumigation with spraying in the Tropics. The experiments were very successful and will be continued.

Fruit growers are taking up the work of protecting their groves from the wind, and the indications are that they are going to have very much cleaner fruit, the scale being taken care of by the beneficial fungi. The importance of planting windbreaks is continually being urged by the station, not only the quick-growing kinds, but strong, hard-wooded trees that will become permanent breaks to withstand the winds and storms of years.

## BEES.

There continues to be great interest in apiculture. Many of the coffee planters are sending men to the station to study methods of beekeeping. During the summer a class of 15 was studying the practical handling of bees, methods of raising them, and the production of honey. The station has sold during the last year a number of nuclei, most of them being sent to coffee estates in the interior.

At the present time there seems to be a very bright future for the bee industry in Porto Rico, as there are no diseases, and where Italian bees are used the moths are not troublesome. It is important to remember that the stock or the strain must be kept up or bees will

become mixed with the black bees, which are not so good as honey producers. When new blood is desired queens only should be imported by mail, as bees brought from other countries are apt to be diseased.

At the last session of the Porto Rico Legislature the following bill was made a law:

That no bee comb, larvæ, pupæ, or bees shall be brought into Porto Rico from any other place: *Provided*, That queen bees, accompanied by not more than 30 worker bees and without bee comb containing eggs, larvæ, pupæ, or bees, may be introduced therein in mailing cages, or small boxes.

A circular on beekeeping in Porto Rico has been prepared and will soon be ready for distribution.

## INSECT PESTS IN CUBA.

June and July of 1910 were spent on the island of Cuba, the expenses of this trip being borne by some of the sugar planters of Porto Rico. The main objects of the visit were to study the cane insects and to obtain, if possible, parasites of the Lachnosterna beetle found in Porto Rico canes. Cuba, no doubt, has this same beetle, but only two specimens were found, one in the collection at Santiago de las Vegas and one in the Gundlach collection at Habana. Many of the planters recognized the beetle from descriptions given and all stated that their flight occurred during March, April, and May, the same time as their flight in the district of Mayaguez, P. R. The flight of this beetle was the same in all parts of Cuba visited—Santiago de Cuba, Habana, Ceballos, Cienfuegos, and Manzanilla. This seems a little strange, as in Porto Rico we have the Mayaguez flight in March, April, and May, while the Guanica flight is during May, June, July, August, and a part of October.

Cuban methods of planting are very different from those practiced in Porto Rico. On new lands the wood is cut and burned. The canes are planted in rows as closely as possibly; no holes are dug, no plowing done, and no stumps removed. The fire kills all the weed seeds, and the first crop comes on very quickly and does not need very much, if any, cultivation.

When canes are cut and the rattoons commence to come up the trash is pulled away from around the stool, and after a certain length of time placed back again, the trash protecting the ground, so that very few weeds have a chance to grow. Although this is not the way all cane is grown in Cuba, it is the usual practice on virgin lands. Often after the first year the cane fields become infested with Johnson grass, which it is very difficult to get rid of. This is one of the plants whose introduction into Porto Rico must be avoided. There is one serious drawback to this system of cropping, and that is that the accumulation of so much trash makes an ideal place for insects and fungi to breed. An examination of the trash showed a great

amount of animal life and fungi, especially root fungi. The Cuban fields which have been in cane a number of years are full of root fungus. The trash was full of canes, which showed that they had been killed by the West Indian rind rot. One reason why Cuba has not had a severe outbreak of diseases is that when the lands become infested they are left, and virgin lands, or lands which have been lying idle for a number of years, are planted.

The cane insects of Cuba are about the same as those of Porto Rico. Canes were seen which had been eaten by the moth borer, shot-hole borer, and the weevil borer. These insects were more abundant in the Cuban fields than in the cane fields here. There seem to be two reasons for this: One is that some years not all the crop is harvested, and the other is that the Cubans cut their canes too high, sometimes leaving from 1½ to 3 inch stubs. This seems a very poor practice, as the planter loses a certain amount of sugar; also, the stalks or pieces of cane make ideal places for fungi and insects to obtain a start. In many fields stools examined showed that the stubs of cane had been destroyed in some cases by fungi, and others showed that insects had cleaned up the canes, as they were, at the time of examination, full of fiber and the cocoons of the cane weevil. On some of the estates visited these conditions did not prevail. They were cultivating their canes, planting legumes between the rows, testing systems of planting, and in some places irrigating. At these estates the canes looked remarkably well, and the tonnage was far above the average Cuban crop.

Cuba's most serious orange troubles seem to be the extended drought which comes during the winter months and the small weevils which scar the fruits. After the first rains in the spring the trees blossom and the weevils appear. The scarring is done by several species. A number of these beetles were collected, and the planters stated that all of them injured the fruit. A number of specimens were seen eating the young fruit of the second blossoming. The fruit of the first blossoming was very badly scarred. Not very much scale was observed, as the groves visited were protected by the beneficial fungi, which were in great abundance. Cuba apparently has not as strong trade winds as Porto Rico, and for this reason alone the scale would not be as bad. Another reason why Cuba does not have a great amount of scale is that many of her groves were originally planted in strips cleared in the forests.

The treatment of orange groves in Cuba is not the same as in Porto Rico. The general practice is to allow the grass to grow in the groves during the rainy season, cutting it as it grows high, and saving it for a mulch to place around the trees during the winter months. This has been practiced during the past season by many, and good results have been shown.

## REPORT OF THE PATHOLOGIST.

By G. L. Fawcett.

### COFFEE DISEASES.

The leaf blight of coffee caused by *Pellicularia koleroga* has been studied during the past year. Especial attention was paid to the life history of the fungus. No ascus-bearing stage was found nor any evidence of propagation by spores. A slow but effective spread of the disease takes place by the dropping of leaves carrying the mycelium or their transportation by the wind to healthy trees, each infested leaf being a source of infection. The fungus makes rapid growth during the season of abundant rainfall, but with the dry season its growth stops, and it gradually dries up and falls away, leaving the trees comparatively clean. Small fragments remain, however, and from these growth is again made when sufficient water is available. It is at the close of such periods of drought that sprayings can be made most successfully. In experiments made here during the past season various fungicides were tested as sprays, several with favorable results. Bordeaux mixture was found to be best, owing to its adhering better to the foliage. Spraying, together with cultural methods, such as careful pruning and the avoidance of too close plantings, promises to control this disease effectually.

More difficulty is encountered in the case of the so-called root disease of coffee, in which the trees are killed by being girdled just below the surface of the soil. At first the disease affects a small area, but gradually and slowly spreads. Although acting so slowly, the total loss is great, especially as the best trees are often attacked. The trouble seems to be favored by the piling up of earth about the base of the trees, especially below hillside paths, and by the accumulation of masses of decaying vegetable matter. Various methods of soil disinfection are being tried, and ditches have been made to prevent the spread of the diseased areas. The experiments will have to be continued through a considerable period of time before obtaining results of any value.

The spot of leaf and fruit caused by *Stilbum flavidum* is really a serious disease of coffee though fortunately restricted to the area of extreme humidity. The life history of this fungus, never fully worked out hitherto, has been studied and an experiment in its control begun. Work has also been done on other minor diseases of coffee on which a report will be made later.

## PINEAPPLE DISEASES.

The cultivation of pineapples in the clay soils of some of the more humid regions is attended with uncertain results. Sometimes the plants during the second or third year after being set out become yellow and do not respond to the usual applications of fertilizer. The roots of such plants have been found to be decayed. An experiment in soil disinfection, making heavy applications of several disinfectants, was carried out in one of the worst affected fields, but without favorable results except in the case of one plat, to which sulphur was applied. Potted plants have not shown any symptoms of this disease nor lost any part of their root systems, though inoculated with a Fusarium common in the diseased plants and in some cases placed in contact with material from these plants. That the inoculated and check plants are equally healthy is probably because it was impossible to duplicate the physical conditions of the field soil. This subject will be studied further, but it would seem now that fungi and bacteria are unable to injure the plants unless soil conditions are very unfavorable.

## MISCELLANEOUS DISEASES.

A disease quite common in one variety of bananas is caused by a fungus which enters through the root and attacks the stem. The fungus, a species of Fusarium, was isolated and a study made of the disease nearly two years ago, but, as the banana is one of the lesser crops and the disease is only occasionally troublesome, no further attention was given to the subject until early in the present year, when serious loss was reported on one of the plantations, which, on investigation, was found to be caused by the same disease as that previously studied. Experiments to determine effective methods of control have been begun. The disease is apparently identical, both as to the causative organism and general symptoms, with a disease very destructive in the banana plantations of Central America.

The diseases of some other plants have been studied so far as time permitted. Among these may be mentioned a bud rot of the coconut, which is found in a few trees in some of the plantations along the west coast. It seems to be identical with the bud rot occurring in the other West Indies, though evidently less contagious. Some attention has been given to the diseases of cane and cacao, though no report will be made until the conclusion of experiments now in progress.

## REPORT OF THE COFFEE EXPERT.

By J. W. van Leenhoff.

Weather conditions were very unfavorable during the past year at and in the vicinity of the coffee substation at La Carmelita. Severe storms during August and November destroyed all hopes for a good crop and for the showing of definite results in the various experiments. The disastrous results of the strong winds could be seen, the soil under and between the coffee trees being literally covered with small coffee plants sprouted from berries blown from the trees. The berries were larger than last year and ranged from 300 to 350 berries per liter.

The emajagua, *Paritium tiliaceum*, planted for windbreaks, is growing well and will soon be in condition to stand a test, but the pavonia, *Hibiscus rosa sinensis*, could not be planted in sufficient quantities because of the difficulty of procuring seedlings.

The new plantings of Porto Rican and foreign coffees continue to do well, and the crop was again used for distribution free of charge to planters and for cup tests. Several samples roasted here were sent to different persons in the States and on the island. Nearly all reports from the cup trials agree as to the excellency of the Maragogype coffee.

The United States market has thus far refused to buy Porto Rican coffees, and one of the reasons for this refusal is said to be a bitter taste of the coffee, to which customers in the States object. The removal of this bitter taste would therefore be a valuable improvement and likely to facilitate the introduction of the coffees into the home market. The successful shipping of roasted coffee from here direct to customers in the United States might open a new field for commerce.

A few trees of an exceedingly fine coffee, Mocha or Inhamban, were discovered in the neighborhood of Mayaguez. Some seeds were collected and planted, with the hope of introducing the cultivation of this fine coffee amongst our planters.

Leaf weevils are still doing very much damage, and experiments for their control have thus far not been successful. The American coffee disease (*Stilbum flavidum*) is rapidly spreading in the vicinity. A special study is being made of this disease by the plant pathologist, and experiments for its control have been begun. Coffee

leaf blight and borers in the shade trees continue on the increase, and thus far no means have been found for their control.

## IMPROVEMENT OF AN OLD COFFEE GROVE.

The experiments on the renovation of an old coffee grove were continued, but owing to the heavy losses of berries by storms, no positive results can be shown. From the 9½-acre tract 2,468 pounds of coffee were harvested and marketed. The collection of data on the cost of producing coffee in the improvement plats has been continued.

*Cost of producing 100 pounds of coffee in renovating experiments, 1910.*

| | |
|---|---|
| Weeding, pruning, etc | $2.70 |
| Harvesting | 1.56 |
| Preparing for market | .60 |
| Freight to market | .39 |
| Total cost per 100 pounds | 5.25 |
| Average price obtained per 100 pounds | 11.03 |

## EXPERIMENTS WITH NEW PLANTING.

A definite report on the experiments to determine the cost of producing a coffee plantation can not be presented, for the reason that the great demand for coffee seed and the large quantities of samples sent out for cup tests made it impossible even approximately to determine the quantity harvested. Besides the seed and samples, there were gathered 163 pounds, which were sold for $18.14.

## REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

Some experimental tappings of 7 and 8 year old Castilloa rubber trees on the station grounds were made. All tappings were made by the herringbone system. On April 15 one of the largest of the 8-year-old trees was first tapped, giving 40 grams of dry rubber; on April 18, the wound being shaved, the yield was 18 grams; being shaved again on April 20 only 10 grams were obtained; making a total of 68 grams of dry rubber. In August all of the trees which were 24½ inches or more in circumference at 3 feet above base, greatest girth being 32 inches and average girth 28⅓ inches, were tapped between 5.15 a. m. and 8 a. m. The main channel cut was about one-half inch wide, shallow, and 6 feet in length. In most cases there were four branch cuts on either side 6 to 8 inches in length, made fairly deep but narrow. The latex did not flow very freely and tended to coagulate on the tree. The incisions made on the tree tapped in April seemed to have widened, if anything, rather than to have made a successful effort at closing the wound. New incisions between the old scars gave almost no latex, but a good flow was obtained from the other parts of the trees, showing the unsuitableness of the herringbone system for Castilloa, as so much of the trunk is covered and the cuts must heal before the areas are retapped. A tree which was tapped on the opposite side the second day after the first tapping gave for the first tapping 16 grams and for the second 39 grams, showing the much greater pressure thrown by tapping into the untapped side. The relative amounts of dry rubber bore no relation to the quantity of latex, one tree yielding 22 grams of dry rubber from less than 100 cubic centimeters of latex, another 17 grams from 400 cubic centimeters of latex. Fourteen trees were tapped, all together yielding in one tapping 279 grams of dry rubber from latex and 70 grams of scrap, or about 25 grams per tree.

Some additional plantings of rubber have been made, including *Mascarenhacia elastica*, *Funtumia elastica*, and *Castilloa* sp.

The vanilla cuttings received in December of last year were somewhat retarded in starting by the long-continued drought which commenced about the time they were planted. They are, however, now in flourishing condition, and several vanillas growing wild in different parts of the island have been added to the collection.

Notes on cacao as to yield and comparative notes on different trees are being kept. The plantings now include some 15 varieties.

Most of the young coffees planted last year are doing well, excepting, however, some planted on a very steep, badly washed slope and which are very much exposed to the sun. Among the young coffees, Padang and Columnaris are doing best. Both Blue Mountain and Ceylon hybrid coffees, which were set from seed bed two years ago, gave very good yields this year, a number of trees in each producing more than a pound of dry coffee. Seed of these and of a few other introduced coffees were distributed to numerous growers. (Pl. III, fig. 1.)

The value of cover crops, manure, various chemical fertilizers, and terraces and ditches on steep slopes to prevent washing are being tried. The experiments as to the manner of and age at which transplanting to permanent location had best be done are being continued, and tests are being made as to the value of applying various amounts of lime to the soil at time of transplanting.

Last year high-growing coffee trees which had lost their lower branches were cut off at distances varying from a few inches above ground to 6 feet. From the renewed growth it seems advisable to cut the trees as low as 6 inches, since in any case the greater part of the crop is lost, only a very few berries being left even when the trees are cut at 6 feet. (Pl. III, fig. 2.) The lower the trunk is cut the lower will be the renewals and the fruit-bearing branches. Some topping experiments have been started on young coffee which has not lost its lower branches. Work is being continued on getting an old plantation into young, lower, and more productive wood rather than leaving old and high-branching trees as they are to bear coffee out of reach of the pickers.

As this plantation is shaded by the ant-infested guama, *Inga laurina*, plantings of numerous leguminous trees were made, which included, besides the native trees, *Albizzia moluccana* and *Pithecolobium saman*, with the idea of eventually eliminating the guama. On the station grounds *Pithecolobium dulce* and *Albizzia stipulata* are also being tried as coffee shade.

Germination tests of coffee and various methods of preserving the viability of the seed are being continued and will be reported upon later.

New plantings have been made of Murta, Kamerun, Hawaiian, Mauritius, Menado, Surinam, and Philippine coffees.

Some work is being done on hybridizing coffees, and at present some small seedlings of *C. arabica*×*C. liberica* and of *C. maragogype*×*C. arabica* are on hand.

Fig. 1.—Coffee Tree in Full Bloom.

Fig. 2.—Coffee Renovation Experiments. Sprouts 1 Year Old from 6-Inch Stump.

## REPORT OF THE ANIMAL HUSBANDMAN.

By E. G. Ritzman.

The work in animal husbandry in the past was, from necessity, primarily limited to the introduction and acclimatization of improved breeds of live stock. As nearly all improved breeds have been brought to their present state of perfection in the more temperate climates, it can easily be seen that such work presents many new problems in the Tropics. It is necessary to bring in stock that will meet the economic conditions of the island and which will best suit other conditions prevailing here.

Climatic conditions differ materially in various parts of the island, owing mainly to the great difference in rainfall. Soil conditions are widely different, and the natural result is that by reason of climate, soil, and vegetation some sections are more favorably suited to stock growing than others. The rainfall is very heavy at the station, ranging from 70 to 90 inches annually, and the soil is deficient in lime. The south side of the island, on the other hand, is comparatively dry, the grasses are more nutritious, and the soil is richer in lime. These conditions prevail also to a certain extent in some localities on the northwest coast. The south side is, therefore, by nature more favorable to stock breeding, and it is there that the larger numbers of stock are bred, especially horses and work oxen.

It is yet a question as to whether it is safer to import young growing stock or mature animals. It can be stated tentatively that in this part of the island mature stock does better, while in the drier sections it would be safe for both young or old. Young stock acclimates quite readily, but old stock will thrive on less nutritious food, especially so far as concerns mineral nutrition. This is well illustrated by a comparison of the stock-breeding industry in the limestone regions of the north with other parts where limestone is less abundant.

Incidental to this work much time has been spent in the erection of suitable buildings, the preparation of paddocks, and in the care and management of the imported stock. From necessity it has involved a study of diseases, their prevention and treatment, with general observations on sanitation. Varying with local conditions, the problems of feeding demand a study of the available feedstuffs and their suitability to supplement the forage crops grown here.

With the progress of time the work is becoming more encouraging, and breeders are now making a demand for improved standards in the live-stock industry.

## HORSES.

Trotting-bred, thoroughbred, and saddle-bred horses have been introduced on the south side of the island, and, as has been stated in previous reports, with the result that a material increase in the size of the stock has already become apparent. The demand for larger horses, especially for the carriage type, is becoming stronger as the agricultural conditions are improving, and good horses command high prices.

The greatest difficulty in making introduction of stock by the station has been encountered with horses. This is largely due to the unfavorable climatic and soil conditions which exist in this part of the island where the experiment station is located. Of the six horses brought from the States during the previous year, three became affected with osteoporosis within four months after their arrival. The animals affected were all yearlings. They were immediately treated with small doses of potassium iodid, and an attempt was made to offset the loss of calcium by giving calcium chlorid in the drinking water or the food. Apparently beneficial results followed in two cases. The two older animals which had reached maturity when brought down have kept in excellent health. As ticks were found on the affected animals, it has been suggested that they may have some relation to the disease. The three older stallions are now in the stud on the south side of the island, two in Coamo and one in Ponce.

The prevalence of glanders is a great drawback to the horse and mule industry here. With proper sanitary measures to prevent further contagion, it could no doubt be eliminated. It exists apparently in a chronic state among native stock, but a number of American mules brought down by sugar planters have contracted an acute form. The station has so far been free from this disease.

## CATTLE.

The chief demand for improved breeds of cattle continues to be for those of the dairy type. Breeders are especially desirous of securing the use of sires of deep milking strains. There have been added to the station herd a Jersey bull calf and a 2-year-old Guernsey bull. The four crossbred Zebu bulls brought from Texas last year are now of breeding age, and have been put at the service of breeders on the south side, where draft oxen are principally grown. They are very active, strong-boned animals, and should therefore add some very desirable qualities to their progeny. Although showing a tendency to be somewhat wild, they were broken to yoke.

Results so far obtained from crossing native cattle with improved beef breeds indicate a prepotency of the improved blood, but only the best type of native cows should be used, else the results may be disappointing. The station now has several head of such crosses. A Hereford cross with her second calf, though a very poor milker, is a very pretty animal, with more spread of frame than her dam and better beef form.

Diseases among cattle are not very prevalent. The greatest damage comes from the ticks, which at certain seasons tend to keep the cattle somewhat emaciated. A disease somewhat resembling apoplexy in its symptoms, locally known as "llaga," occurs not infrequently. Blackleg has occurred periodically in certain sections, but is being combated by the use of vaccine. Minor affections, such as grubs and parasites from stagnant water, are apt to become troublesome if not promptly attended to.

## HOGS.

The demand for pure-bred hogs for breeding purposes has been steady throughout the year. Thirty head were sold during the year. The principal drawback to the development of the hog industry is the scarcity of proper feedstuffs and the high cost of those available, together with a lack of knowledge of the principles of feeding. The work in mineral nutrition with pigs begun last year has been continued, and the results will soon be published.

## SHEEP.

In crossing the African woolless with native sheep the result in the majority of cases showed a dominance of the characteristics of the white native, except as to wool. Native sheep possess a poor mutton form, and in the majority of cases a very patchy, inferior fleece. The African sheep has brown hair, and males usually possess horns. As a mutton sheep, they also leave much to be desired. A Southdown ram has been added to the flock, and an attempt will be made to produce a sheep that retains the mutton qualities of the Southdowns with hardiness of the African sheep.

An attempt was also made during the year to graze sheep in coffee land. If successful, it would solve a problem of cheap pasturage and at the same time add fertility to the soil. It was soon found to be impractical, as some weeds or grasses were injurious to the sheep. Four lambs became very sick, two of them died within a week, and the others soon afterwards, and the whole flock was out of condition for some time. It was found that they did not attack coffee where other good grazing was available, but as soon as pasture ran low they ate young twigs and leaves. There has been some

demand for African sheep for breeding purposes, and 17 head have been sold to various parts of the island during the year.

## POULTRY.

The demand for eggs and poultry during the past year has been very strong. Forty-two chickens, barred Plymouth Rock and single-combed White Leghorns, have been sold for breeding purposes. In addition, 14 head of Pekin ducks and about 150 settings of eggs of these breeds and of Bronze turkey and Toulouse geese have been sold for a similar purpose.

No disease has so far affected the grown poultry, but considerable loss has occurred from sorehead among young stock. Many young chicks have been saved by treatment with tincture of iodin. This treatment, however, must be applied with great care.

## STOCK FEEDS.

The high prices of concentrated stock feeds is at present a great drawback to the live-stock industry in Porto Rico. This naturally applies more to some classes of stock than to others. Hogs, for example, can not be developed at their best without concentrates, and poultry will not produce without a proper balance of nutritious food. The supply kept by dealers is somewhat limited in variety, chiefly owing to the small demand for such feeds. Stock growers have not yet learned to select feeds which are best suited to certain purposes or to balance rations. Corn, about the only grain crop grown, forms the basis for poultry feed, and it is used largely for horses. Hogs, on the other hand, live largely on kitchen slops, fruits, and seeds from the royal palm. Corn often retails at prices which are much higher than the cost of slaughterhouse and milling by-products if their relative feeding value is considered. It is not likely that a local production of concentrates will develop. Forage crops, however, could be grown to some extent to supplement in part the present scarcity.

When planters come to appreciate the relative value of different stock foods they will be able to grow their stock more economically as well as to produce better animals.

○